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SE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

MISSOURI HEADWATERS BASIN
AGNES LAKE DAM
BEAVERHEAD COUNTY, MONTANA
MT-817

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PREPARED FOR:

HONORABLE TED SCHWINDEN
GOVERNOR, STATE OF MONTANA

BURK RANCHES
KAMBICH RANCHES
JOHN G. ROUSH
(OWNER/OPERATOR)

PREPARED BY:
HOSKINS-WESTERN-SONDEREGGER, INC.

APRIL, 1981

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EXECUTIVE SUMMARY

Under contract with the Seattle District Corps of Engineers and with representation from the State of Montana Department of Natural Resources and Conservation and the dam owners, Agnes Lake Dam was inspected by Hoskins-Western-Sonderegger, Inc., on 20 September 1979, under the authority of Public Law 92-367. Agnes Lake Dam is located in Beaverhead County, Montana, approximately 23 miles north-northwest of Dillon.

This report was compiled from information obtained during an on-site inspection, a review of operation records, and analysis of hydrologic and hydraulic data. Findings were compared to engineering criteria currently accepted by most private and public agencies engaged in dam design, construction, and operation.

PRINCIPAL FINDINGS AND EVALUATIONS

Agnes Lake is intended to be used for irrigation storage and, secondarily, for recreation. It is owned and operated jointly by Burk Ranches, Kambich Ranches, and John G. Roush under a special-use permit from the U.S. Forest Service. The project consists of a natural lake and an embankment to raise the lake elevation for irrigation storage. The reservoir has a drainage area of approximately 2.6 square miles, a surface area of about 114 acres at normal pool, and total storage at dam crest of about 1860 acre-feet, of which about 600 acre-feet is natural storage.

In accordance with the "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1), the 13-foot-high Agnes Lake Dam (MT-817) is classified as being intermediate in size based on storage in the reservoir. Brown's Lake Dam, a 12-foot-high earth dam, is located about 1.5 miles downstream of Agnes Lake Dam. At the time of inspection, Brown's Lake Dam appeared to be in poor condition. Based on a visual inspection and engineering judgment, failure of Agnes Lake Dam would cause overtopping and subsequent failure of Brown's Lake Dam and could affect 2 residences and 1 campground downstream. Consequently, Agnes Lake Dam has a significant (Category 2) downstream hazard potential. A dam breach hydrograph analysis is required to accurately evaluate the downstream hazard; however, such an analysis is beyond the scope of this inspection.

Inspection criteria (Ref. 1) recommend that an intermediate-sized project with a significant downstream hazard potential be capable of safely handling a spillway design flood (SDF) in the range of one-half of the probable maximum flood (PMF) to the full PMF. The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. We recommend that the SDF for Agnes Lake Dam be one-half of the PMF.

During the dam safety analysis, an estimated PMF was developed for the drainage basin resulting from a 24-hour storm. The resulting PMF has a volume of approximately 2060 acre-feet. The reservoir level at the beginning of the 24-hour storm was assumed to be at the spillway crest elevation. Reservoir routings of the estimated 24-hour PMF indicate that the project will handle approximately 30% of the PMF volume before overtopping if the low-level outlet is fully open. The dam could erode and fail when overtopped by flood waters.

On the basis of the field inspection and the study of hydrologic and operational data, Agnes Lake Dam does not conform to the recommended guidelines with respect to discharge and/or storage capacity to safely handle the recommended SDF.

Evidence of minor foundation or embankment seepage was found at the maximum embankment section. No piezometers are installed to measure water levels in the embankment, and there is no known internal drainage system. Conditions described in this report suggest that the dam does not conform to the recommended guidelines (Ref. 1) with respect to the stability of the downstream slope. However, there is insufficient information to evaluate stability.

PRINCIPAL RECOMMENDATIONS

Develop and immediately place into operation a downstream warning plan, for use in the event of possible embankment failure. Inspect the conduit, the control gate, and the conduit inlet structure wing walls during a period of low pool elevation. Repair the conduit outlet wingwalls, and construct a trash rack at the inlet structure. Establish a formal maintenance plan. Remove all bushes and root systems from the embankment, and eliminate all rodent populations on the embankment. Adequately backfill and compact resulting holes.

Conduct more-detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity. These studies should include an analysis of the effects of a dam breach on the downstream area. Determine embankment stability. Modify the project as studies indicate.

Prior to performing engineering studies and remedial construction, coordiante all work with the U. S. Forest Service and the State of Montana Department of Natural Resources and Conservation to insure compliance with all laws and regulations.

Stephen H. Nickel
Professional Engineer

PERTINENT DATA

1. GENERAL	
Federal Identification Number	MT-817
Owner/Operator	Burk Ranches Kambich Ranches John G. Roush
Purpose	Irrigation, recreation
Location	Sections 3 & 4, T4S, R10W Beaverhead County, Montana
Watershed	Tributary to Rock Creek
Downstream Hazard Potential	Significant
USGS Quadrangle (15-minute)	Vipond Park, Montana
2. RESERVOIR	
Surface Area at Normal Pool (Spillway Crest)	114 acres
Normal Storage (Spillway Crest)	1420 acre-feet
Total Storage (Minimum Dam Crest)	1860 acre-feet
Surcharge Storage	440 acre-feet
Natural Storage	600 acre-feet
Drainage Area	2.6 square miles
Reservoir Water Surface Elevation (9/20/79)	7501.6 feet (NGVD)
3. SPILLWAY	
Type	Uncontrolled earth channel
Crest Elevation	7505.9 feet (NGVD)
Width (Crest)	13 feet
Spillway Capacity (Minimum Dam Crest)	560 cfs

4. OUTLET WORKS

Type	Controlled concrete conduit
Controls	Slide gate with manual control
Size	24-inch x 24-inch pentagonal
Length	48 feet
Inlet Invert	7499.0 feet (NGVD)
Outlet Invert	7496.6 feet (NGVD)
Normal Tailwater	Unknown
Discharge Capacity (Minimum Dam Crest)	70 cfs

5. DAM

Type	Earth
Maximum Height (Hydraulic)	13 feet
Crest Length	230 feet
Minimum Crest Elevation	7509.7 feet (NGVD)
Crest Width	8 feet
Upstream Slope	1(V) on 2(H)
Downstream Slope	1(V) on 3(H) upper 4 feet; 1(V) on 1/4(H) below (rock wall)

CHAPTER 1

BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of Agnes Lake Dam, which is owned and operated by Burk Ranches, Kambich Ranches, and John G. Roush of Dillon, Montana.

The National Dam Inspection Act, Public Law 92-367 dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-federal dams throughout the United States. Pursuant to that authority, the Office of the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1) in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists, highly experienced in dam safety, from many federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary the guidelines outline a two-phased study procedure for investigating and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety condition of the dam;

(2) based upon an evaluation of the available data and a visual inspection;

(3) performed to determine if any emergency measures and/or additional studies, investigations and analyses are necessary or warranted; and

(4) not intended to include extensive explorations or analyses or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, materials testing, hydraulic and hydrologic analyses, and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies, but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigations outlined above are intended only to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the dam owner and the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act and neither any action nor failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify conditions that threaten public safety, so that they may be corrected in a timely manner by non-Federal interests.

1.1.3 Inspection

The findings and recommendations in this report were based on visual inspection of the project and an interview with the owners. Records of Forest Service inspections dating back to 1941 were supplied for reference. No design drawings or foundation exploration results were available for review or analysis. Inspection procedures and criteria were those established by the Recommended Guidelines for Safety Inspection of Dams (Ref. 1).

Personnel present during the inspection included:

Louis Boitano, Civil Engineer, Seattle District Corps of Engineers;
Art Taylor, Civil Engineer, State of Montana, Department of Natural Resources and Conservation (DNRC);
Vern Burk, Owner;
Gerald Burk, Owner; and
Don Kambich, Owner.

Hoskins-Western-Sonderegger, Inc. (HWS) personnel who participated in the field inspection and contributed to this report are:

Stephen Nickel, Geotechnical Engineer, Team Leader;
Mike McMeekin, Hydrologist/Hydraulics Engineer; and
Gene Holtorf, Hydrologist/Hydraulics Engineer.

This report has been reviewed by representatives of the owners, the U. S. Forest Service, and the Montana State Department of Natural Resources and Conservation. Written comments from the U. S. Forest Service and the Montana DNRC have been included in the Appendix of this report. The owners did not comment.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

Agnes Lake is a high mountain lake owned and operated jointly by Burk Ranches, Kambich Ranches, and John G. Roush. The project is operated under a special-use permit from the U. S. Forest Service. The main purpose for the facility is to store snowmelt and rainfall for irrigation during the following growing season. Agnes Lake Dam (MT-817) is located in Sections 3 and 4, T4S, R10W, Beaverhead County, Montana, approximately 23 miles north-northwest of Dillon on a tributary of Rock Creek.

Agnes Lake's natural storage capacity of about 600 acre-feet was increased to a total capacity of approximately 1860 acre-feet with the construction of Agnes Lake Dam in 1928. The drainage area is approximately 2.6 square miles. A 13-foot-wide, uncontrolled, earth spillway is located in the right abutment of the dam. The dam has a 24-inch x 24-inch concrete pipe, low-level outlet, which is used to control the amount of discharge from the lake during the irrigation season.

Agnes Lake Dam is 13 feet high and, at the minimum dam crest elevation of 7509.7 feet, impounds approximately 1260 acre-feet of water with a surface area of about 124 acres. The dam, therefore, is classified as intermediate in size based on storage in the reservoir. Brown's Lake Dam, a 12-foot-high earth dam, is located about 1.5 miles downstream of Agnes Lake Dam. At the time of inspection, Brown's Lake Dam appeared to be in poor condition. Based on visual inspection and engineering judgment, failure of Agnes Lake Dam would cause overtopping and failure of Brown's Lake Dam, which could affect 2 residences and 1 campground located downstream. Consequently, Agnes Lake Dam has a significant (Category 2) downstream hazard potential.

1.2.2 Regional Geology

The Pioneer Mountains lie in the southwest corner of Montana. They are bounded by the Anaconda Range to the north, the Beaverhead Mountains in the Bitterroot Range to the west across the Big Hole valley, and the Ruby and Tobacco Root Ranges to the east across the Beaverhead Valley.

The Pioneer Mountains are essentially composed of a complex suite of igneous rocks, the Boulder Batholith, which has intruded into the much older sedimentary and metamorphic rocks of the area. The intrusion of the Boulder Batholith, along with intensive block and thrust faulting, has been the

major factor in the geologic structure of the Pioneer Mountains. Present topography is the result of Pleistocene glaciation and valley fill in the lower intermountain areas.

The northern Rocky Mountain region, prior to Late Cretaceous time, was essentially a flat plain partially flooded by shallow seas. At the end of the Mesozoic Era, of which the Cretaceous is the last geologic epoch, this entire area became geologically active. Three things exemplify this activity: (1) Cretaceous uplift; (2) Late Cretaceous thrust faulting; and (3) Late Cretaceous-Tertiary intrusive activity, i.e., the Boulder Batholith. The regional uplifting of the continental crust brought the earth up in several north-south trending blocks. The west sides of the faulted blocks, or mountains, are higher in elevation and have characteristically abrupt scarps, while the east sides of the blocks have long, gentle slopes.

The uplifted land became subjected to erosion. As the sediments were transported downslope, they filled the intermountain valleys with debris ranging from muds and sands to gravels and cobbles. These valley-fill sediments attain a depth of several thousand feet in the axis of the mountain valleys.

Pleistocene alpine glaciation of Wisconsin Age (12,000 years before present) sculptured typical alpine glacial features, including cirques, headwalls, and troughs in the upper elevations of the Pioneer Mountains. In lower elevations, glacial deposits of terrace gravel, stream bed alluvium, landslide rubble, and glacial drift occur.

1.2.3 Seismicity

Agnes Lake Dam (MT-817), located in the Pioneer Mountains, lies in Seismic Zone 3 as indicated by the Seismic Zone Map (Ref. 1). The seismic probability of this regional setting is one of potential for major damage and is based on the known distribution of damaging earthquakes in the region.

The Preliminary Map of Young Faults in the United States, by the U. S. Geological Survey (Ref. 2), indicates suspected activity along the northern expanse of the Pioneer Mountains and Holocene activity directly east, along the northwestern side of the Tobacco Root Range. The Geologic Map of Montana shows extensive faulting prior to the Cenozoic Era in the southern portions of the Pioneer Mountains.

Local earthquakes significant enough to be reported in References 3 and 4 occur in 2 epicentral areas. One of these is to the northeast along a line from 20 miles northwest of Helena to 25 miles north of Bozeman, while the other is to the southeast in northeast Idaho, northwest Wyoming, and the adjoining areas of Montana. Of these two epicentral areas the former is 75 to 100 miles northeast and the latter is 50 to 150 miles southeast of the project site. Two earthquakes of significant intensity that occurred in

the tri-state region southeast of the project site were the Hebgen Lake, Montana, earthquake (8 August 1959), that had an intensity of X (Modified Mercalli), and another southeast of Dillon, Montana, and southeast of the project area (23 November 1947), that had an intensity of VIII. The three largest reported earthquakes northeast of the Pioneer Mountains have had intensities of VIII. One of these earthquakes had its epicenter at a point 25 miles north of Bozeman (27 June 1925), while the other two occurred at Helena (18 October and 31 October 1935).

In the vicinity of the project there have been numerous other earthquakes in this century (Ref. 3 and 4). In an area bounded by the 44th and 46th parallels and by the 110th and 112th meridians (including the tri-state region), there have been more than 50 earthquakes iwth intensities of V and more than 10 with intensity of VI. The closest reported earthquakes to the project site have occurred approximately 50 miles east near Ennis and Virginia City, Montana. The largest of these had an intensity of VI and occurred near Ennis (10 March 1977). The exact distance from the epicenter of this earthquake to the project site is not known.

The Pioneer Mountains lie in a highly seismically active area with the potential for a damaging earthquake. This warrants special attention be given to the dams in the area that have been constructed without consideration of the effects of earthquakes.

1.2.4 Site Geology

Agnes Lake lies in the outcrop area of the quartz monzonite rocks of the Torrey Mountain batholith. Immediately east of the lake is the contact between the batholith and the locally north-trending, upturned sedimentary rocks of Mississippian age.

Slopes in the drainage area vary from 35% to 60% at the higher elevations to 20% to 40% nearer the lake. Soil development at the higher elevations consists of a moderately thick regolith and moderately deep, well-drained sandy loam having clay loam subsoils. Nearer the lake there is a moderately deep, well-drained, dark-colored, gravelly sandy loam.

Agnes Lake is retained by a moderately frost-churned glacial moraine with moderately steep (20% to 40%) slopes and a moderately thick regolith (rock mantle). Moderately deep to shallow, well-drained, coarse sandy loams characterize the patchy soil development. The dam is constructed on this moraine.

1.2.5 Design and Construction History

According to the owners, the dam was constructed after water had been mined from Agnes Lake for several years by lowering the natural outlet elevation with dynamite. The embankment was built to block the altered outlet and permit the regulation of flow for irrigation.

According to Forest Service records and the date inscribed on the conduit inlet headwall, the dam was constructed in 1928. The records show that the conduit was set 7 feet below the previously existing grade and 13.5 feet below the crest of the embankment. Plans show a 10-inch concrete core wall near the embankment center line.

CHAPTER 2

INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Spillway

The spillway for Agnes Lake is located at the right abutment of the dam. The spillway is an excavated earth channel, as best seen in Photos 5 through 8. Approximate dimensions and elevations were determined in the field for use in the calculation of the discharge capacity of the spillway.

The control section for the spillway is located approximately at the extended center line of the dam. The slope of the channel downstream from the control section is about 3%. The channel has an average bottom width of 13 feet, and the sides have slopes of approximately 1(V) on 3(H). The channel was free of debris, and a log boom, which appeared to be fairly new, protected the channel from debris. The channel showed signs of some usage but appeared to be in good condition. The only evidence of erosion damage was located about 75 feet downstream from the dam and was very minor.

The discharge rating curve for the spillway was determined by assuming that critical depth occurs at the control section and computing water surface profiles, with Manning's "n" = 0.03, upstream into the reservoir. The discharge capacity varies from 0 cfs at the normal pool elevation of 7505.9 feet to about 560 cfs at elevation 7509.7 feet, the minimum crest elevation of the dam. The complete discharge rating curve for the spillway is shown on Plate 7.

2.1.2 Outlet Works

The low-level gravity outlet for Agnes Lake consists of a 24-inch x 24-inch pentagonal concrete conduit (Photo 10-outlet, Plate 9-sketch of concrete pipe cross section), with a vertical slide gate to control the rate of flow through the pipe (Photo 9-control structure). The length of the outlet conduit is approximately 48 feet. A sketch of the dam cross section, including the outlet conduit, is shown on Plate 3. The inlet elevation of the conduit is 7499.0 feet, which is 10.7 feet below the minimum crest elevation of the dam and 6.9 feet below the normal pool elevation. The outlet invert elevation is 7496.6 feet, and the resulting slope of the pipe is 5%.

A visual inspection of the upstream end of the conduit was not possible, as it was under water at the time of the inspection. However, there was no trash rack to prevent debris from accumulating at the entrance or plugging the conduit. The slide gate was completely shut and locked in place with a chain and padlock. There was water flowing from the conduit at the rate

of approximately 1/4 cfs. An inspection of the downstream end of the outlet conduit indicated that the outlet was in fairly good condition, although some signs of concrete deterioration were apparent. The remainder of the outlet conduit was not inspected.

The channel downstream from the outlet conduit is an excavated earth and rock channel which has an approximate slope of 3%. There is a considerable amount of brush and vegetation in the channel downstream from the outlet (Photo 11). Very little erosion damage was evident, and this was mostly confined to the area near the outlet conduit; however, this erosion poses no threat to the integrity of the embankment.

The outlet discharge rating curve (Plate 8) was computed assuming full pipe flow discharge, with no tailwater restrictions and the slide gate completely raised. The discharge capacity for the low-level outlet works is approximately 55 cfs at the normal pool elevation of 7505.9 feet and approximately 70 cfs at the minimum crest elevation of the dam, 7509.7 feet.

2.1.3 Freeboard

The fetch for wind-generated waves is about 1140 feet, and the wave run-up and set-up on the embankment is estimated to be 1.7 feet (Ref. 5). A 3.8-foot difference exists between the normal pool elevation of 7505.9 feet and the minimum dam crest. This is considered adequate in preventing wave overtopping (Ref. 6).

Routings indicate that no freeboard exists during the recommended SDF. At the time of inspection, the irrigation season was drawing to a close, and the pool elevation was about 8.1 feet below the minimum crest elevation. Thus, at the time of the inspection, the freeboard was adequate to prevent wave overtopping.

2.2 HYDROLOGY, CLIMATOLOGY, AND PHYSIOGRAPHY

2.2.1 Climatology and Physiography

The climate of the area around Agnes Lake is continental and characterized by a large diurnal and seasonal temperature range. Extreme variability of wintertime temperatures results from the frequent occurrence of chinook winds, which follow a Pacific maritime air mass invasion. The summers are characterized by warm days with low humidity and cool nights. Winters are cold and highly variable in severity from year to year.

Dillon, in Beaverhead County, at an elevation of 5218 feet is the climatological station nearest the project site. The precipitation and climatological data available from this station are not applicable to the project because of a 2288-foot elevation difference between Agnes Lake and the weather station. The average annual precipitation for Agnes Lake, as estimated from

Soil Conservation Service graphs, is 40 inches (Ref. 7). The average expected date of the first freeze at the project site is August 13th, and the average expected date of the last freeze is July 9th (Ref. 8).

Agnes Lake is located on a tributary to Rock Creek in the Pioneer Mountains and in the Beaverhead National Forest. The drainage basin above and including Agnes Lake has an area of about 2.6 square miles. Basin elevations range from the normal pool elevation of 7505.9 feet to 9019 feet on top of Call Mountain. The average ground slope is about 13%. Basin vegetation consists of moderately thick pine and grasses on the lower basin area to sparse pine and rocky surfaces on the upper basin area (see Photos 1, 2, 3, and 6).

2.2.2 Reservoir Storage and Spillway Discharge

The reservoir has a surface area of about 114 acres and a total storage of about 1420 acre-feet at the spillway crest elevation of 7505.9 feet. Storage equal to approximately 440 acre-feet is available between the spillway crest and the minimum crest elevation of the dam, 7509.7 feet. The spillway discharge at the minimum dam crest is approximately 560 cfs. The discharge capacity of the facility would increase an additional 70 cfs with the control gate of the low-level outlet fully opened.

2.2.3 Estimated Probable Maximum Flood

The probable maximum flood (PMF) is defined as the flood expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. A storm, the intensity of which approached probable maximum precipitation (PMP) intensity, did occur in parts of Montana in June 1964.

Inspection criteria (Ref. 1) recommend that an intermediate-sized project with a significant downstream hazard potential be capable of handling a spillway design flood (SDF) in the range of one-half of the PMF to the full PMF. Because of the involved risk for this project, we recommend that the SDF be one-half of the PMF.

A PMP storm of 24-hour duration was applied to the Agnes Lake drainage basin. The 24-hour, 12-hour, 6-hour, and 1-hour PMP depths were estimated from National Weather Service Technical Paper 38 (Ref. 9) to be 15.1 inches, 12.8 inches, 10.4 inches, and 6.4 inches, respectively. All 6-hour increments from 0 to 24 hours were arranged in accordance with criteria in Weather Bureau Hydrometeorological Report No. 43 (Ref. 10).

The PMF was assumed to result from a PMP storm in the late spring over frozen ground. Thus, a constant loss rate of zero was applied throughout the 24-hour PMP storm in accordance with Corps of Engineers recommendations. For this reason the overall configuration of the 24-hour storm is not affected by losses, and the basin rainfall is equal to the basin runoff for all storm increments. Direct precipitation onto the surface of the reservoir was also added with no losses.

2.2.4 Flood Routing

For purposes of routing the PMF through Agnes Lake, the lake level at the beginning of the PMP storm was assumed to be at the spillway crest elevation of 7505.9 feet. This would correspond to the normal pool condition. The total volume of the 24-hour PMF for Agnes Lake is approximately 2060 acre-feet with a peak flow rate of approximately 22,560 cfs. Two routings were made. The first routing indicated that, with the control gate of the irrigation outlet closed, the lake will handle, through storage and spillway discharge, approximately 30% of the PMF volume before the dam is overtopped. The second routing assumed the control gate on the outlet pipe to be completely open. This resulted in the lake handling approximately 33% of the PMF volume before the dam is overtopped.

The PMF inflow hydrographs were developed using the SCS dimensionless unit hydrograph. These hydrographs were generated and combined using the HEC-1 (Dam Safety Version) computer program (Ref. 11). The flood routings of the PMF were made using the Modified Puls method contained in the HEC-1 program.

2.3 GEOTECHNICAL EVALUATION

2.3.1 Embankment

The 13-foot-high earth dam is 195 feet long and has a crest width of 8 feet. The upstream slope is 1(V) on 2(H). The upper 5 feet of the downstream face is sloped at 1(V) on3(H). Below this point, filling the narrow outlet channel, there is a hand-laid rock wall, inclined at approximately 4(V) on 1(H). Borrow for the embankment appears to have been obtained locally. Much, if not all, of the borrow appears to have come from the spillway excavation. No other borrow area was readily visible. The material exposed on the crest of the dam is a silty sand matrix, containing gravel and cobbles. This material is readily erodible. The upstream face of the dam is covered with rock riprap, ranging in size from 6 inches to 48 inches in diameter.

Those areas of the embankment not covered by rock are approximately 70% covered with native weeds and grasses and small juniper and willow bushes. Some large trees are growing on the embankment slopes near the abutments, where the embankment is generally less than 2 feet high. In these locations the trees and their root systems are not considered to be a threat to the embankment.

The rock riprap and the downstream rock wall appear to be of igneous origin. The coverage and protection appears adequate. No evidence was found of a granular bedding or filter course between the riprap and the silty sand embankment material. The presence of sags or bulges on the upstream face could not be determined because of the irregularity of the embankment and the large size of the riprap relative to the size of the embankment (see Photos 1 and 2). No sags or bulges were found on the crest or on the downstream face. Rodent damage was found on the crest and the downstream slope.

Forest Service records refer to a concrete core wall in Agnes Lake Dam, although no surface evidence of a concrete core wall was seen. The depth and extent of the core wall, if it exists, are unknown.

2.3.2 Foundation Condition, Seepage, and Drainage

The dam is probably founded on soil similar to that used in its construction. This silty sand material is considered to be quite pervious. At the downstream toe of the embankment near the conduit outlet, there is vegetative seepage evidence, in the form of willow bushes. In addition, a considerable amount of moss is growing above the conduit outlet, and water has stained the concrete headwall and wing walls at the conduit outlet. Although no water was found flowing from these areas, it is speculated that higher lake levels will produce noticeable seepage.

There was no evidence to indicate that the dam included any type of internal drainage system. There are no piezometers installed in the dam.

2.3.3 Stability

Although there is no evidence of sags or bulges on the crest or downstream face, the steep downstream slope (4V:1H) rock wall, coupled with a possible high phreatic surface, suggest that embankment stability does not conform with the inspection guideline criteria. There is insufficient information available, however, to adequately evaluate stability.

2.4 PROJECT OPERATION AND MAINTENANCE

2.4.1 General

Operation and maintenance of Agnes Lake Dam is the responsibility of the owners, with technical assistance provided by the Forest Service. Although a formal plan for operation and maintenance of the lake and dam facilities is not known to exist, U. S. Forest Service inspection reports dating back nearly 40 years infer the above responsibilities. In addition, the reports indicate the dam has had a history of maintenance problems, primarily in the slowness with which regular maintenance is performed. Access to this project is extremely difficult, which limits regular maintenance operations to those which can be performed by hand.

2.4.2 Dam

There is no formal plan for performing periodic maintenance on Agnes Lake Dam. Inspection reports and correspondence indicate insufficient maintenance for at least the last 25 years. Some maintenance has been performed, but usually it has been neither sufficient nor timely. Maintenance currently is needed particularly on the conduit outlet wing walls, the head gate, and the operating controls, including the access catwalk.

2.4.3 Reservoir

As with the dam, the reservoir has no formal plan for operation and maintenance and has received very little attention for many years. A small amount of debris, mostly dead trees, can be seen on the shore of the lake. This debris appears to be no threat to the embankment or spillway.

2.4.4 Warning System

There is no formal warning system or plan of action to warn downstream inhabitants or interests in the event of impending dam failure.

CHAPTER 3

FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of Agnes Lake and Dam, supplemented by analysis of the project in terms of the recommended guidelines' performance standards, resulted in the following findings.

3.1.1 Size, Hazard Classification, and Safety Evaluation

In accordance with inspection guidelines, Agnes Lake Dam is classified as intermediate in size and, based on our visual inspection and judgment, has a significant downstream hazard potential. The recommended spillway design flood (SDF) for this project is one-half of the PMF. Based on reconnaissance level investigations, the project is incapable of handling one-half of the PMF. Agnes Lake Dam, therefore, does not comply with inspection guidelines with respect to discharge and/or storage capacity.

3.1.2 Embankment Dam

As noted in Section 2.3, there is evidence of seepage at the maximum embankment section, above the conduit outlet. The location of the phreatic surface cannot be determined, because there are no piezometers or other instruments installed in the dam. Rodent damage is visible on the crest and the downstream slope.

The steep downstream slope and the evidence of seepage suggest that the stability of the dam does not conform to inspection guidelines. However, there is insufficient information available to completely evaluate stability.

3.1.3 Spillway

The spillway for Agnes Lake Dam was found to be in good repair. The only evidence of erosion damage was located about 75 feet downstream from the dam and was very minor. The channel was free of debris and a log boom, which appeared to be fairly new, protected the channel from debris. It is doubtful that the high channel flows which would accompany a storm of PMP magnitude would cause appreciable damage to the channel or be a threat to the integrity of the dam.

3.1.4 Outlet Works

The 24-inch x 24-inch pentagonal concrete pipe low-level outlet appeared to be in fairly good condition. As previously stated, due to the inlet being submerged, close examination of the inlet and control gate was impossible. The conduit outlet structure showed some concrete deterioration, but not enough to affect the integrity or operation of the pipe. The outlet, as well as the inlet, was free of debris. However, a trash rack which would protect the inlet from debris was not evident. The

access walkway to the outlet controls is in badly deteriorated condition and is a hazard to anyone who would try to operate the gate (see Photo 9). It is also an attractive nuisance for persons who might choose to camp at Agnes Lake.

Although the control gate was closed, a considerable amount of water was finding its way into the conduit. This water must come either from leakage around the gate or from seepage through possible cracks in the conduit.

3.1.5 Spillway and Reservoir Capacity

The reservoir storage capacity and spillway discharge capacity are insufficient to prevent overtopping during the recommended SDF. This investigation has determined that during the 24-hour PMP storm, the dam can handle approximately 30% of the PMF volume with the control gate closed, and approximately 33% of the PMF volume with the control gate open.

3.1.6 Operation and Maintenance

Operation and maintenance are performed by the owners with technical assistance provided by the Forest Service. The project is operated under a special-use permit from the Forest Service. There is no formal operation plan for the reservoir. Water from runoff is stored in the reservoir and is released from the outlet as needed for irrigation. Consequently, the lake level fluctuates seasonally.

There is no formal maintenance plan for the dam, and the facility has a history of inadequate maintenance. The poor condition of the outlet control works and access walkway, the deterioration of the conduit outlet wing walls, and bushes on the embankment are all indications of the lack of sufficient maintenance.

There is no formal warning system or plan of action to warn downstream inhabitants in the event of impending dam failure.

3.2 RECOMMENDATIONS

Due to storage between normal pool and dam crest, the present project provides a degree of flood protection to the downstream area. The intent of the following recommendations is to maintain or improve project safety, if feasible, without decreasing this existing flood protection. The findings suggest that priority be given to the following recommendations:

1. Immediately develop, implement, and periodically test an emergency warning plan for use in the event of dam overtopping. Include the downstream Brown's Lake Project in this plan.

2. Inspect the control gate and outlet conduit, and determine the source of the water entering the conduit when the control gate is closed. Take necessary corrective measures.

3. Construct a trash rack at the inlet structure.

4. Remove bushes and their root systems from all embankment surfaces, and eliminate rodent populations on the embankment. Adequately backfill and compact the resulting holes.

5. Repair the deteriorated concrete wing walls at the conduit outlet.

6. Conduct more-detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity. Modify the project as studies indicate. The studies should include determination of the effects of a dam breach on downstream areas.

7. Determine embankment stability. The study should be performed by a qualified and experienced geotechnical engineer. Modify the embankment as studies indicate.

8. Develop and implement a periodic maintenance plan for the dam and appurtenant structures. Because of the remoteness of the project site, the maintenance plan should include frequent condition inspections whenever water is impounded above the natural lake level.

9. Establish a program for periodic, comprehensive, safety inspections at no more than 5-year intervals. These inspections should be performed by engineers qualified in the design, construction, operation, and maintenance of earth dams.

Prior to performing engineering studies and remedial construction, coordinate all work with the U.S. Forest Service and the State of Montana Department of Natural Resources and Conservation to insure compliance with all laws and regulations.

REFERENCES

1. U. S. Army Corps of Engineers, Office of the Chief of Engineers, Report to the U. S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspections of Dams", Washington D. C., Department of the Army, May 1975.

2. Howard, K. A., et al, "Preliminary Map of Young Faults in the United States as a Guide to Possible Fault Activity," U. S. Geological Survey, Reston, Virginia, 1978.

3. U. S. Geological Survey, "Earthquake Information Bulletin," Washington D. C., 1973-1978.

4. U. S. Department of Commerce, Earthquake History of the United States, Publication 41-1, Washington D. C.

5. U. S. Army Corps of Engineers, Office of the Chief of Engineers, "Wave Run-up and Wind Set-up on Reservoir Embankments," Engineer Technical Letter No. 1110-2-221.

6. U. S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, Water Resources Technical Publication, U. S. Government Printing Office, Washington D. C., 1974.

7. U. S. Department of Agriculture, Soil Conservation Service, "Average Annual Precipitation in Montana," Portland, OR, 1977.

8. Caprio, J. M., "Montana: Average Dates of Freeze," Folders No. 81, 82, and 83, Montana Agricultural Experiment Station, Montana State College, Bozeman, Montana, March 1965.

9. U. S. Department of Commerce, Weather Bureau, Generalized Estimates of Probable Maximum Precipitation for the United States West of the 105th Meridian, Technical Paper No. 38, U. S. Government Printing Office, Washington D. C., 1960.

10. U. S. Department of Commerce, Environmental Science Services Administration, Weather Bureau, Probable Maximum Precipitation, Northwest States, Hydrometeorological Report No. 43, Washington, D. C., November 1966.

11. U. S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Users' Manual for Dam Safety Investigations, Davis, California, September 1978.

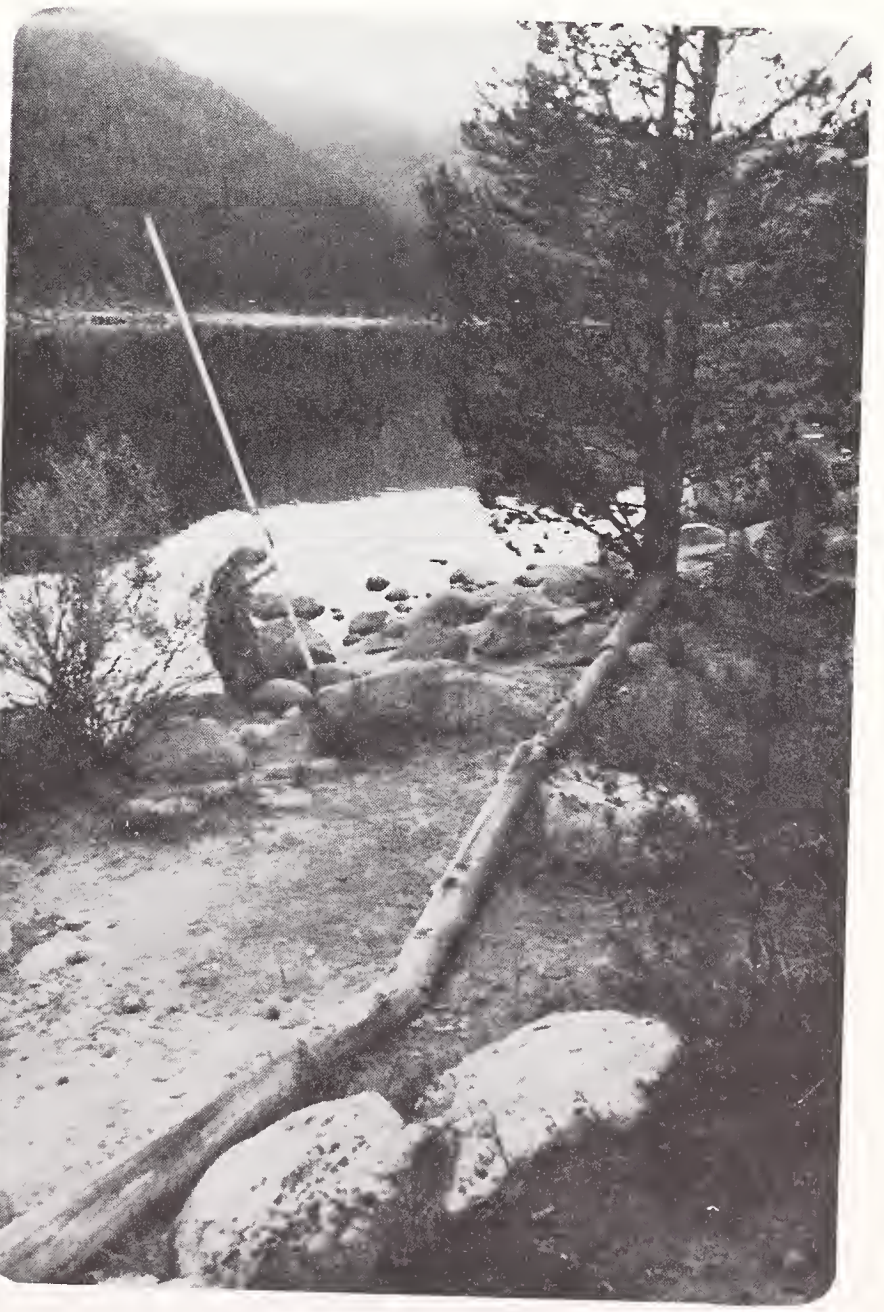
(PHOTO 1) Upstream Face From Left Abutment

(PHOTO 2) Upstream Face From Right Abutment

(PHOTO 3) Downstream Face

(PHOTO 4) Dam Crest From Left Abutment

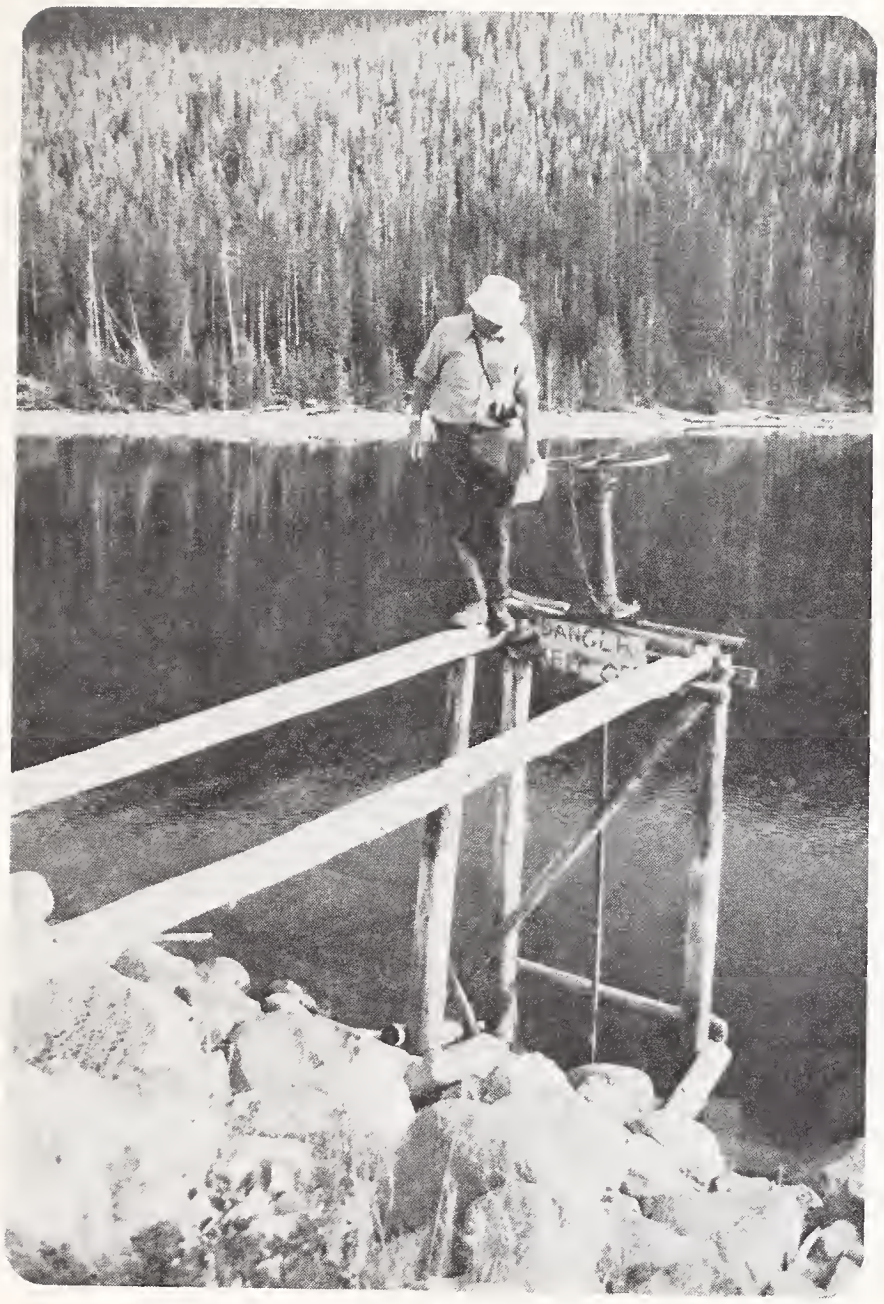
(PHOTO 5) Spillway Control Section and Dam Crest From Right Side of Spillway



(PHOTO 6) Spillway Approach and Log Boom

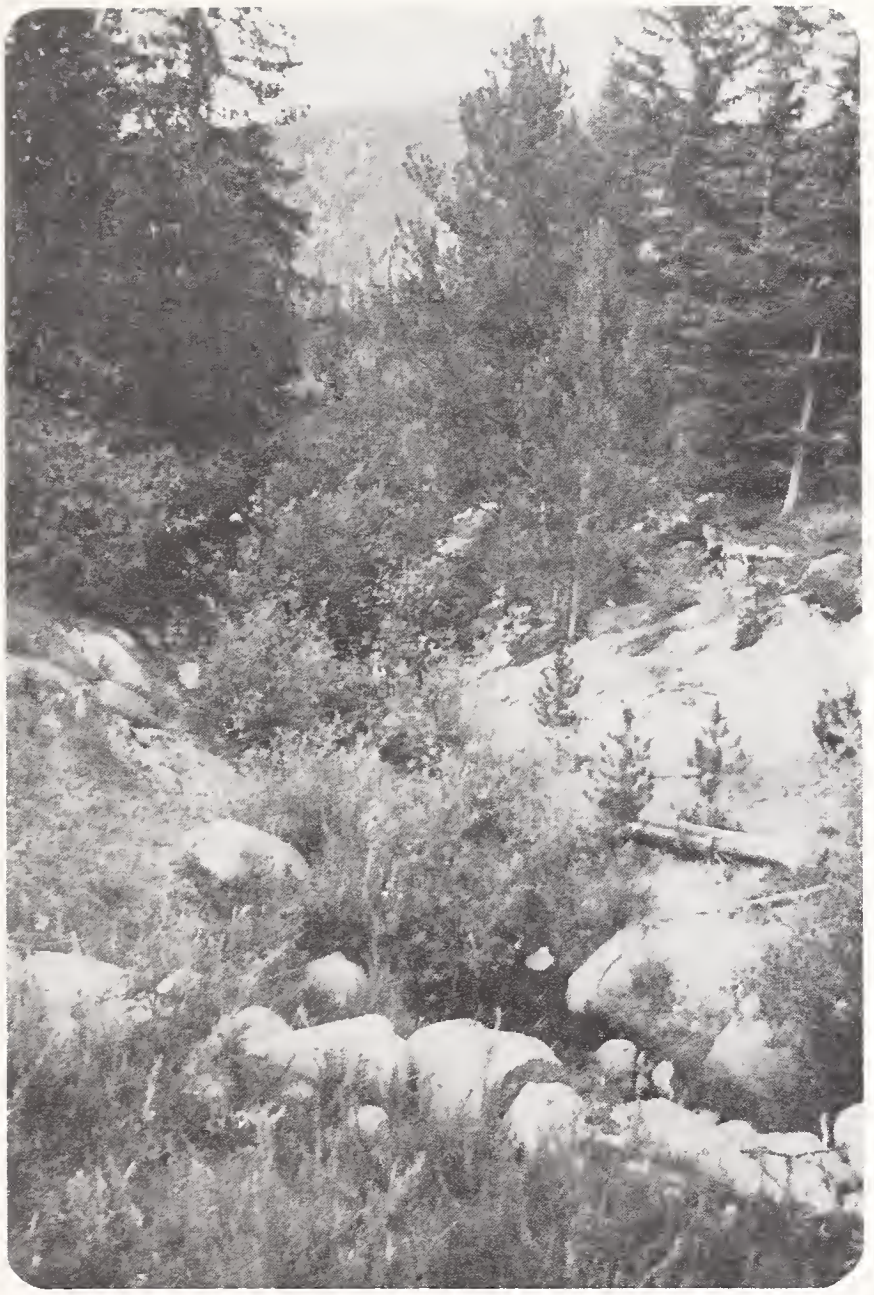
(PHOTO 7) Spillway, Looking Downstream From Approach

(PHOTO 8) Spillway Exit Channel,
Looking Downstream

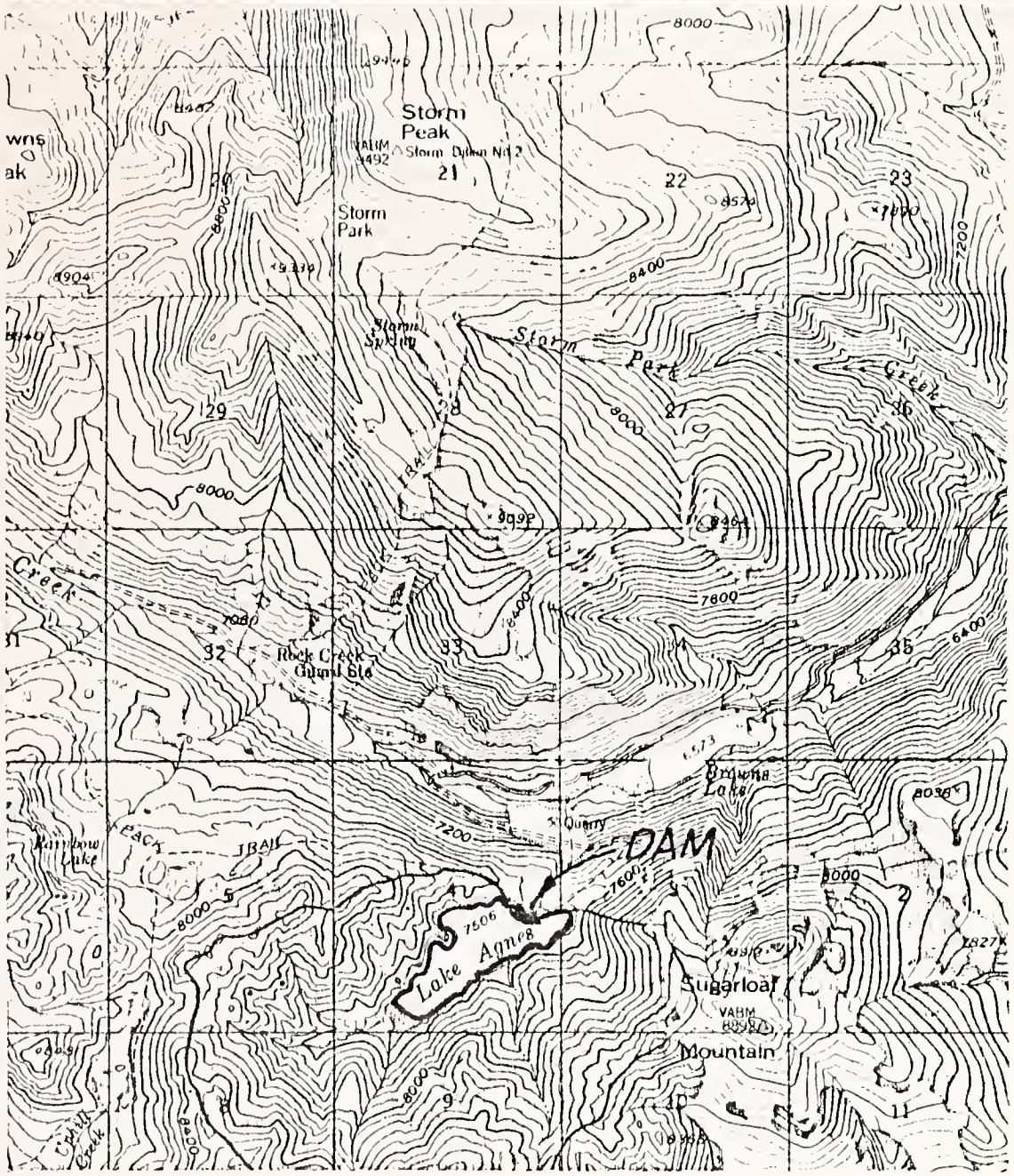


(PHOTO 9) Low-Level Outlet Controls

(PHOTO 10) Conduit Outlet Structure



(PHOTO 11) Outlet Channel, Downstream



SITE PLAN

VICINITY MAP

PLATE 1
AGNES LAKE DAM (MT.-817)
SITE PLAN & VICINITY MAP

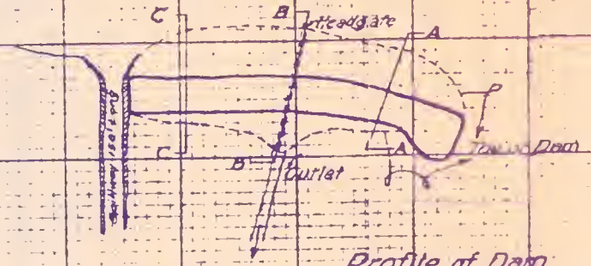
F-Water Power-Beaverhead-
Investigation-Agnes Lake Dam
U(E) Uses-Taclavich, Val Reiber,
Chris Rambich, Stephen 8-4-26

AGNES LAKE DAM

Sec. 4 T 45 S. R 10 W.

Plan View of Dam and Spillway

Scale: 1" = 50'



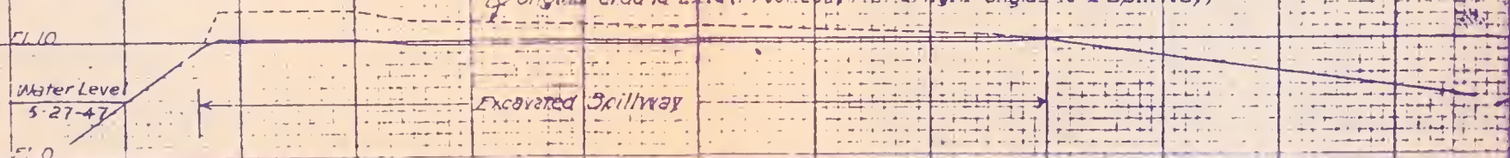
Profile of Dam

Scale: Hor. 1" = 20', Vert. 1" = 10'

Looking Up Stream

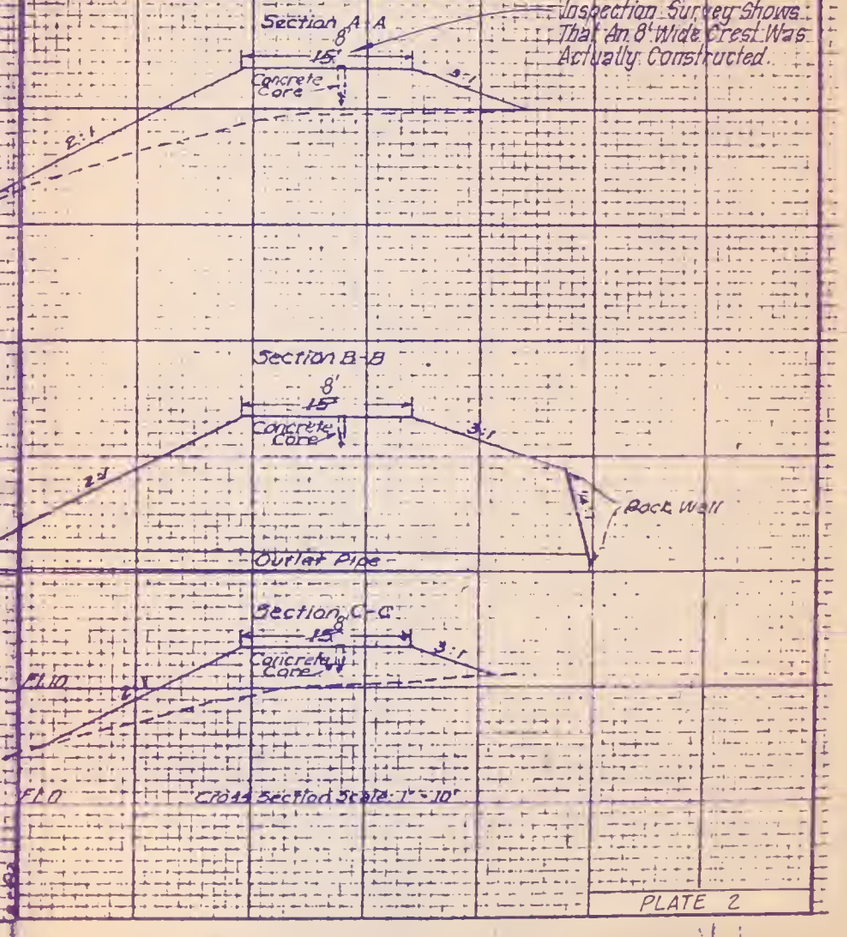
Profile of Spillway

Scale: Hor. 1" = 20', Vert. 1" = 10'



Cross-sections of Dam

Inspection Survey Shows That An 8' Wide Crest Was Actually Constructed

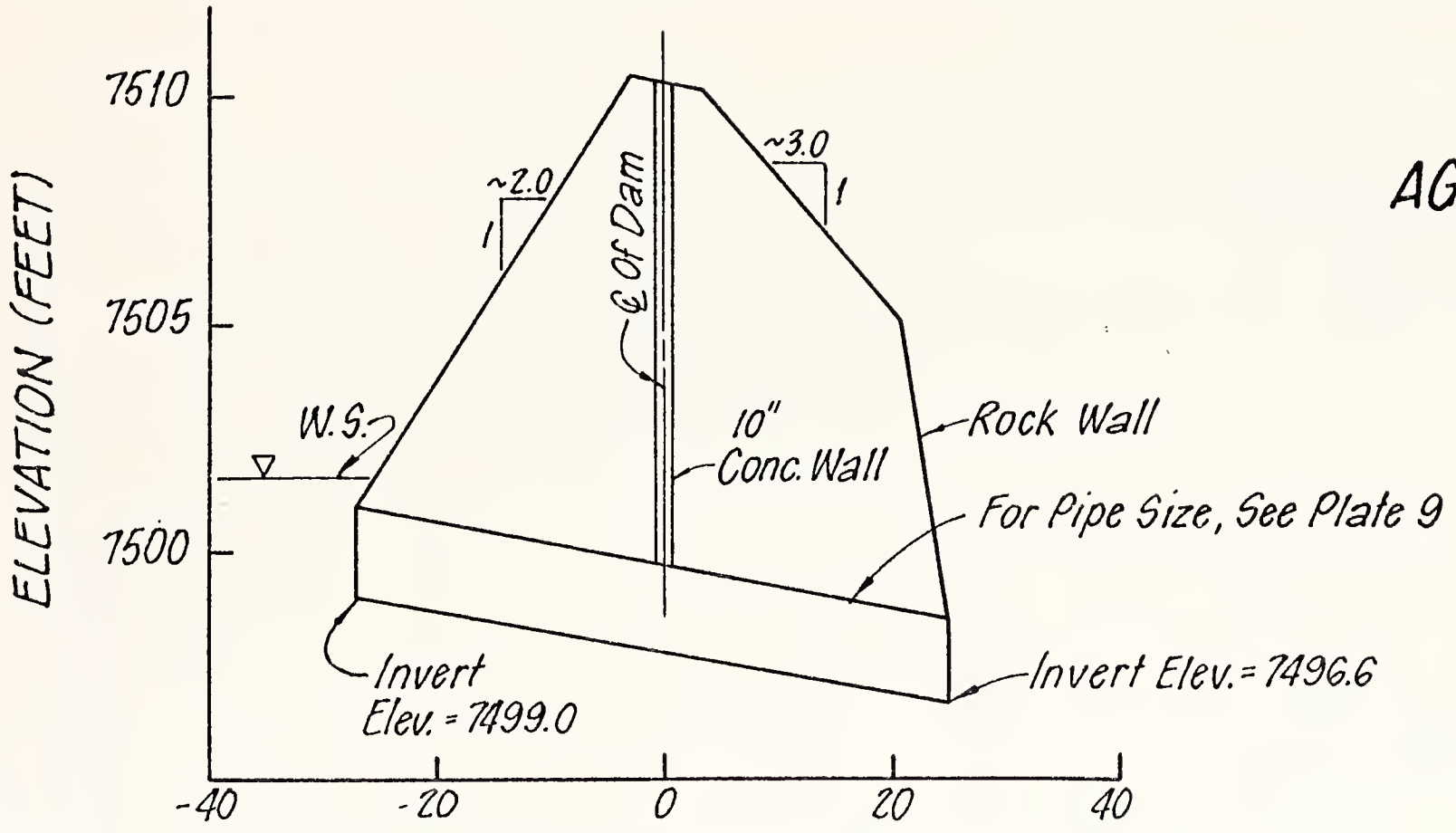


Cross Section Scale: 1" = 10'

PLATE 2

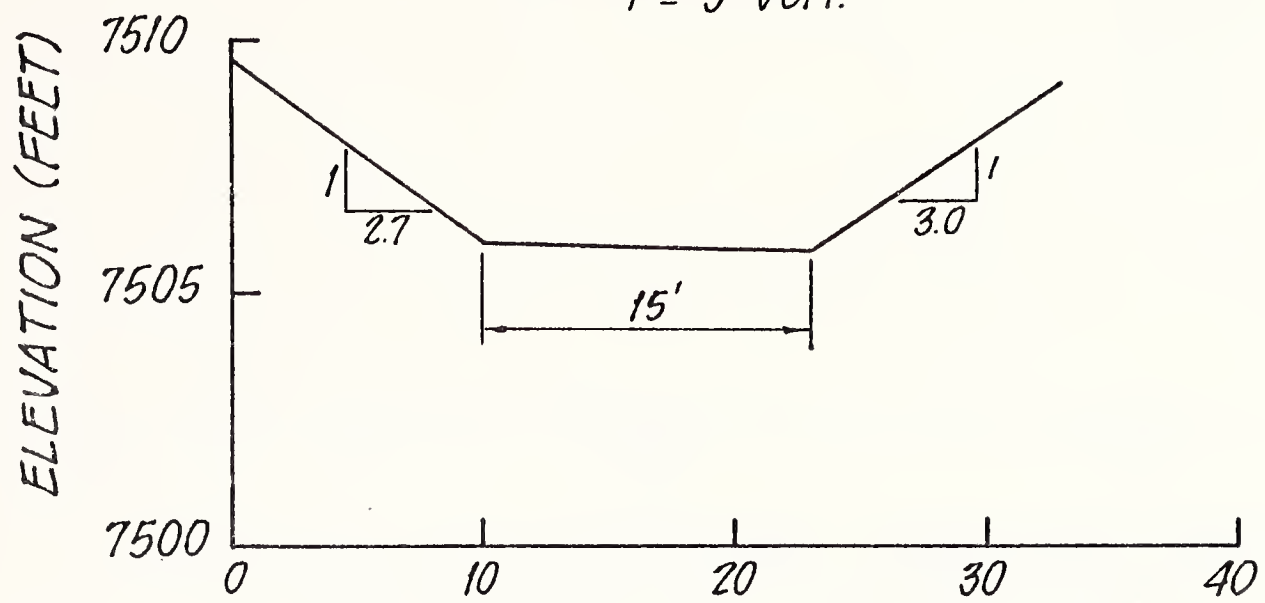
To accompany Memo dated June 20, 1947

AGNES LAKE DAM
Montana



CROSS-SECTION OF DAM

Scale: 1" = 20' Horiz.
1" = 5' Vert.

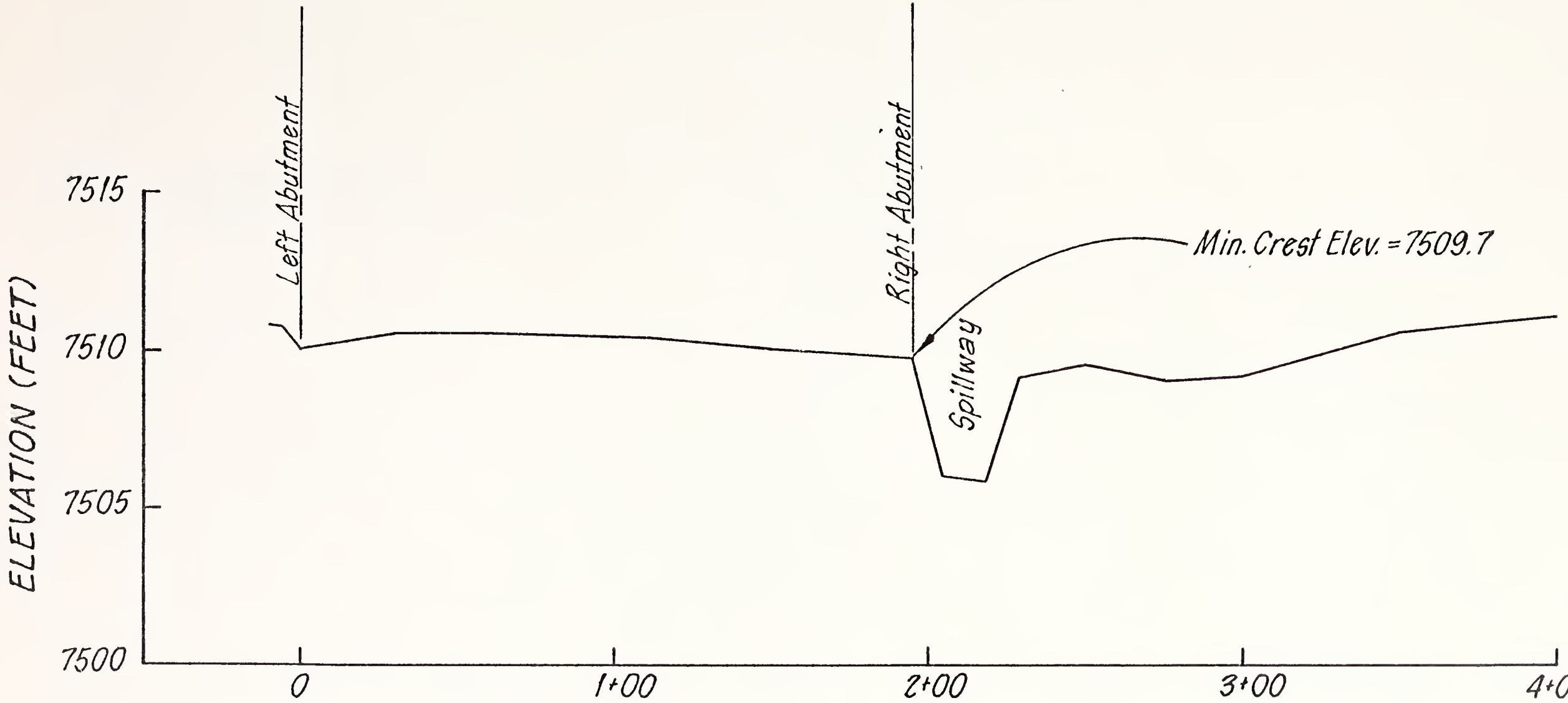


CROSS-SECTION OF SPILLWAY

Scale: 1" = 10' Horiz.
1" = 5' Vert.

PLATE 3

AGNES LAKE DAM
Montana

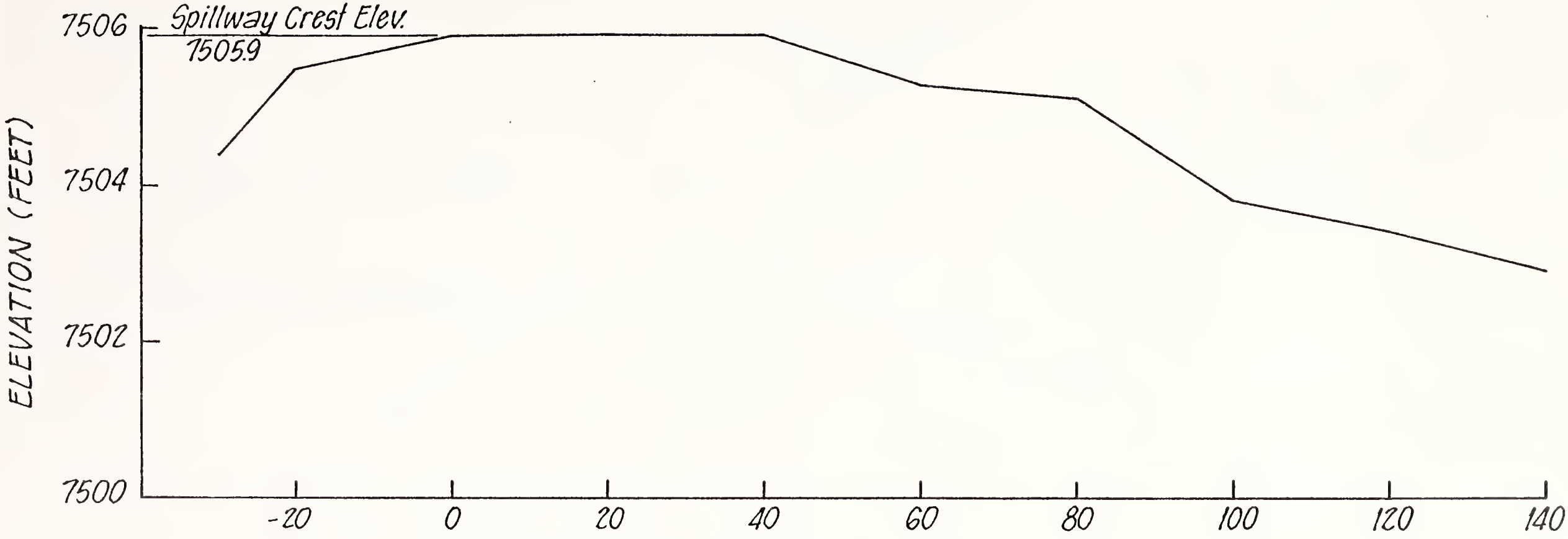


EXISTING DAM PROFILE

Scale: 1" = 50' Horiz.
1" = 5' Vert.

PLATE 4

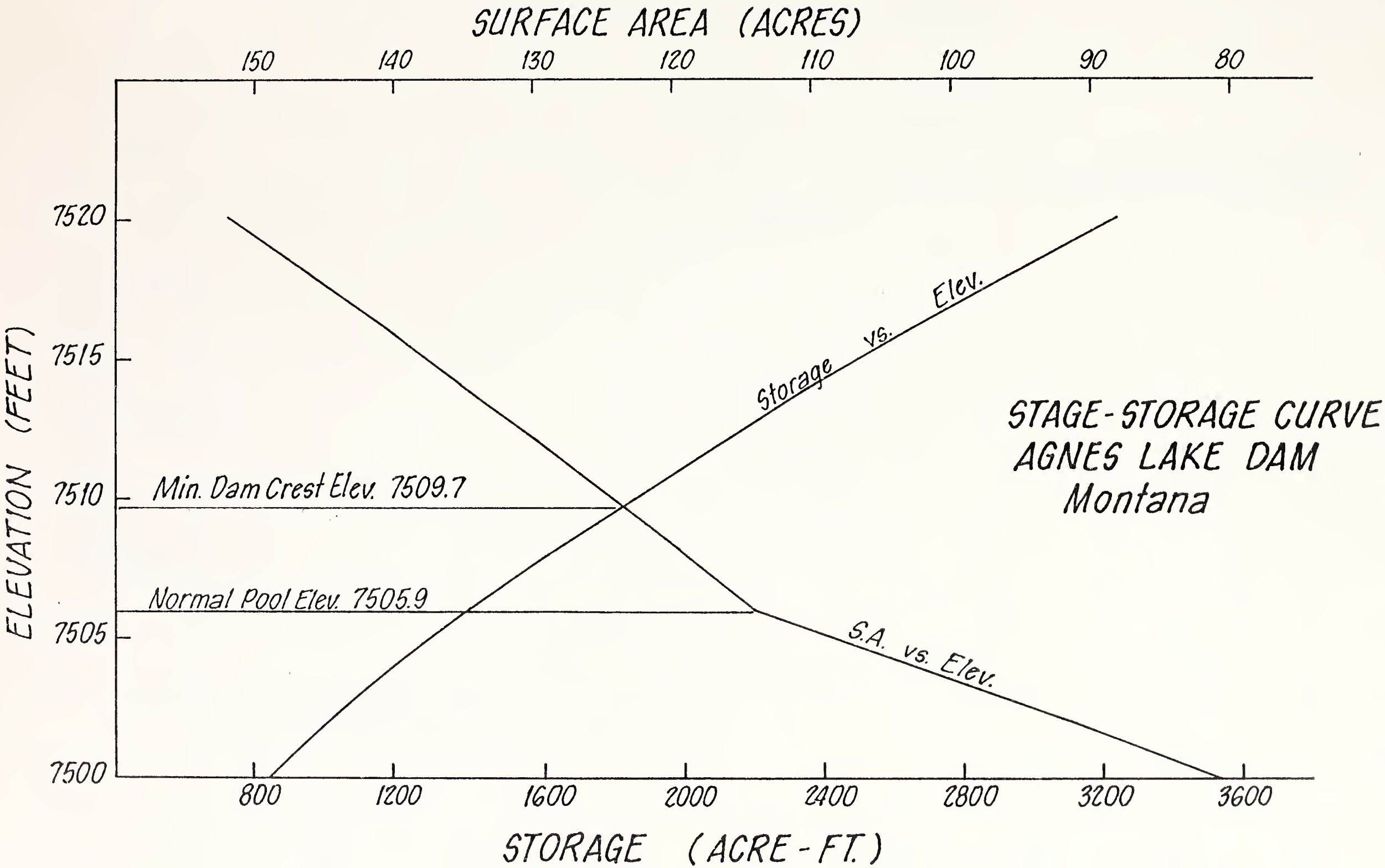
AGNES LAKE DAM
Montana



SPILLWAY PROFILE

Scale: 1" = 20' Horiz
1" = 2' Vert.

PLATE 5



STAGE-STORAGE CURVE
AGNES LAKE DAM
Montana

PLATE 6

SPILLWAY DISCHARGE CURVE

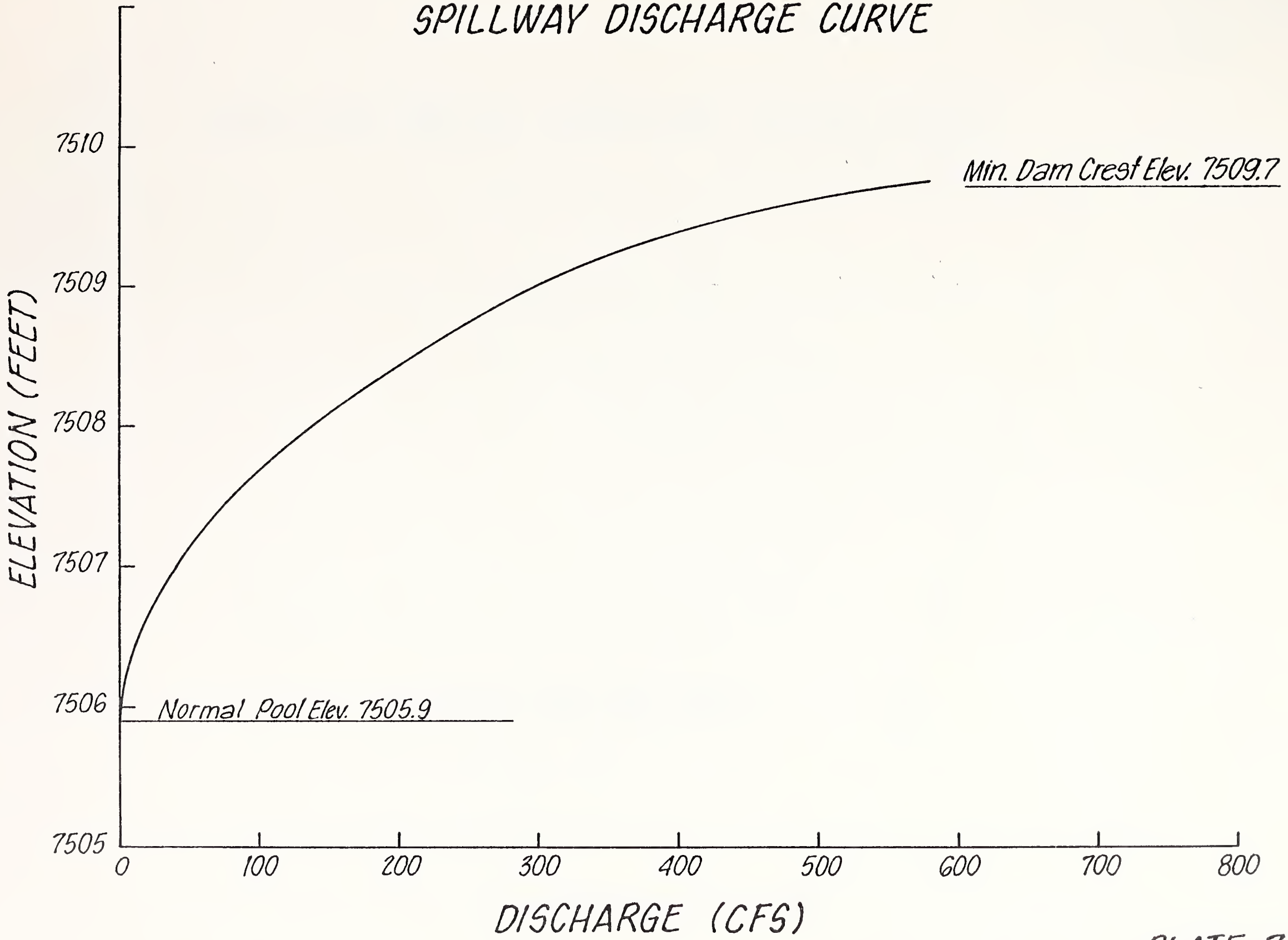


PLATE 7

AGNES LAKE DAM
Montana

LOW-LEVEL OUTLET DISCHARGE RATING CURVE

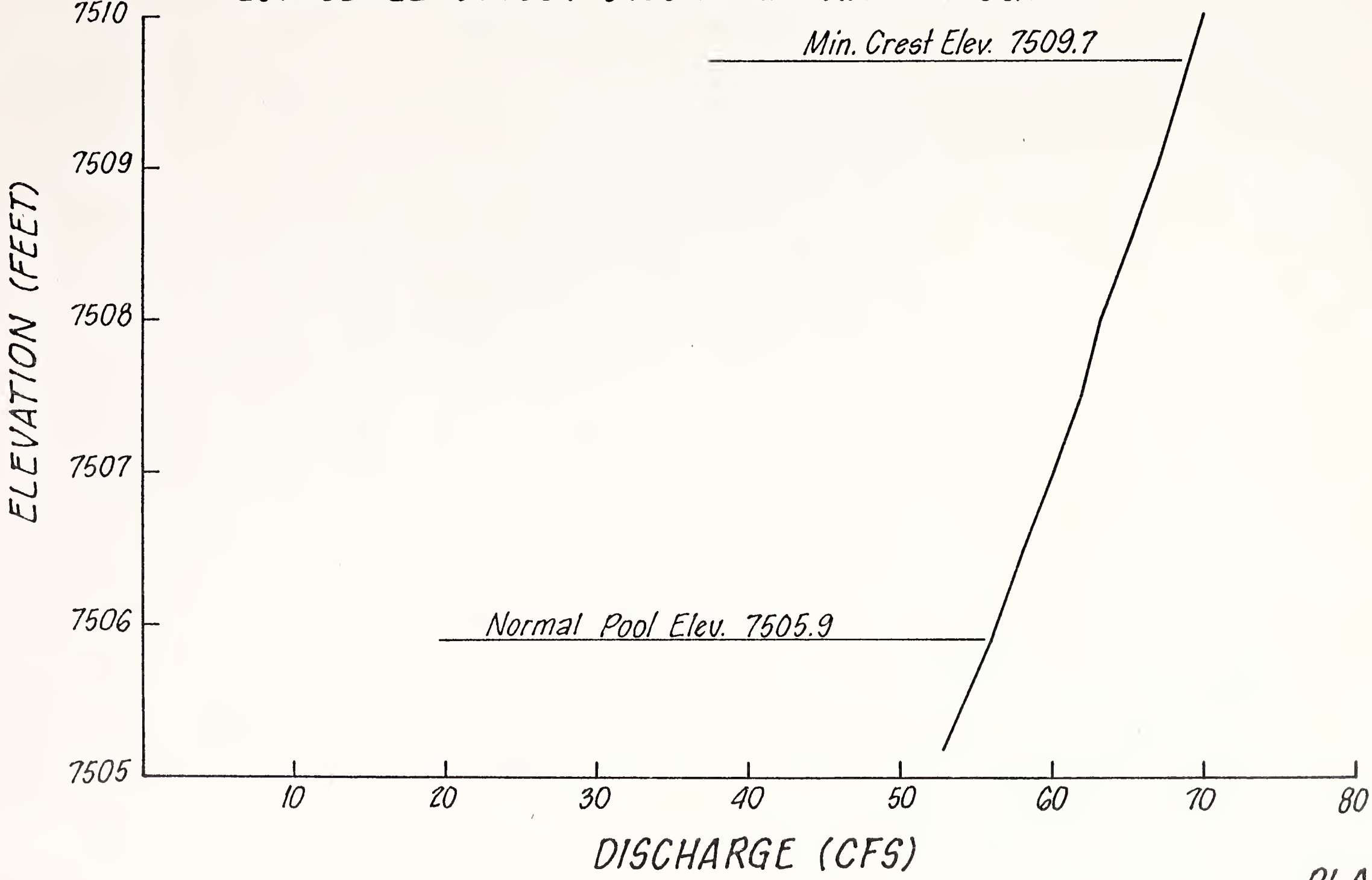
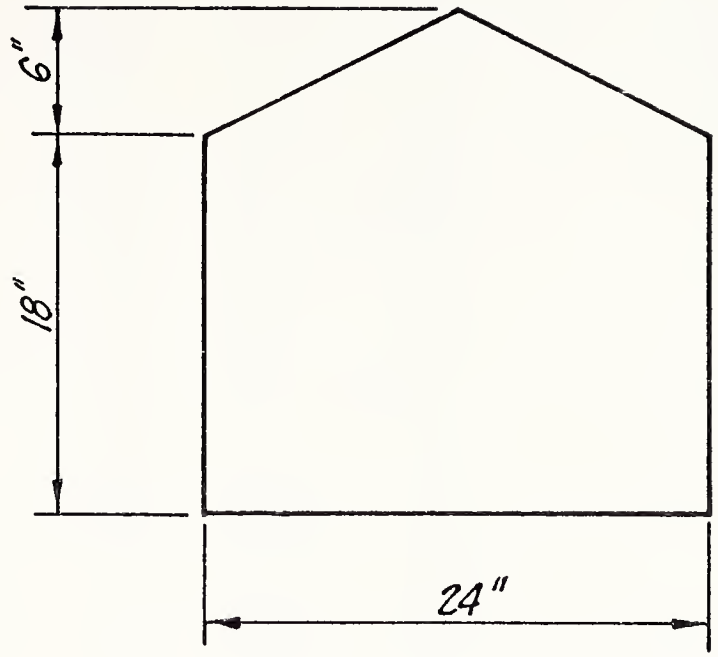


PLATE 8

CROSS-SECTION LOW-LEVEL CONCRETE OUTLET PIPE AGNES LAKE DAM



NOTE: All Dimensions Given Are Interior Dimensions And The Walls Are Between 3" And 4" Thick.

PLATE 9

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR

32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872

HELENA, MONTANA 59601

December 5, 1980

Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Attn: Ralph Morrison

Re: Hoskins-Western-Sonderegger, Inc. Dam Safety Report on Anges Lake Dam.

Dear Ralph:

We have reviewed the above referenced final draft report. We concur with the findings and recommendations and find that it satisfies the criteria of the Phase I report.

Minor editorial comments have been discussed with your staff, and we understand these will be incorporated in the final report.

Thank you for this opportunity to review and comment on the final draft report on Agnes Lake Dam.

Sincerely,

Richard L. Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB/AT/lj

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FEDERAL BUILDING MISSOULA, MONTANA 59801

DEC 3 1980
7530

Sidney Knutson, P.E.
Assistant Chief, Engineering Division
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Dear Mr. Knutson:

We have reviewed the final draft of the Phase I inspection of Agnes Lake Dam and have the following comments.

We agree that a more detailed hydrologic study should be made with a flood routing routine of a breached dam to better define the hazard the dam presents.

Sincerely,

R. W. LARSE
Director
Engineering